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PRESERVATIVE TREATMENTS AND SERVICE LIFE OF FENCE POSTS IN PUERTO RICO

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RESUMEN

En Puerto Rico desde el 1944 se han estado investigando las técnicas de preservación de postes para cercas usando los métodos sin presión más económicos. Recientemente se han establecido estudios de campo y la mayor parte de los postes instalados tienen un servicio de 3 1/2 años. Los postes tratados por cuatro métodos sin presión y usando cinco agentes químicos han sido instalados en cuatro localizaciones de prueba. Los métodos usados son como sigue: (1) ramojo frío, (2) remojo frío y caliente, (3) postes tratados verticalmente, (4) postes tratados por doble difusión por los extremos. Los agentes químicos usados son: (1) creosota, (2) pentaclorofenol, (3) carbolina, y (4) dos combinaciones de sales en doble difusión. Alrededor de 6,000 postes tratados y sin tratar representando 68 especies están bajo estudio.

Este informe inicial que incluye todos los estudios llevados a cabo en este Instituto describe en detalle los materiales usados, métodos de tratamiento, retenciones químicas, terreno y clima en cada estudio y las condiciones de los postes hasta septiembre de 1963. Aunque la mayor parte de los postes ha estado en servicio por menos de cinco años, hemos llegado a las siguientes conclusiones:

1. Los postes sin tratar tienen un promedio de vida útil de 1 1/2 años.

2. Los postes instalados en áreas de elevaciones altas tienen menos fallas que postes similares localizados en áreas de elevaciones bajas.

3. Aunque localmente el efecto de la polilla (los termes) es serio, la podredumbre causada por hongos es responsable de la mayor parte de las fallas.

4. Los postes tratados en una posición vertical con el tope hacia abajo por remojo frío en pentaclorofenol con aceite "diesel" absorben más preservativo que los postes tratados horizontalmente.

5. Los tratamientos de baño frío y caliente usando pentaclorofenol o creosota tienen a esta fecha menos de 10 por ciento de fallas; la vida útil promedio de los postes tratados por estos métodos no se puede predecir exactamente pero los tratamientos similares usando carbolina indican que la vida útil debe ser 15 años o más.

6. Los postes tratados por el método de sales de doble difusión aplicados por inmersión completa del poste resultaron más durables que los postes tratados por difusión con el tope hacia abajo.

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SUMMARY

Low investment non-pressure wood preservation techniques for fence posts have been under investigation in Puerto Rico since 1944. Only recently, however, extensive field trials have been established and most of the test posts have been in service for 3.5 to 4.5 years. Posts treated by four non-pressure techniques (cold-soaking, hot-and-cold bath, steeping, and end-diffusion) using five wood preservation chemicals (creosote, pentachlorophenol, carbolineum, and two double-diffusion salt combinations) are now set out at four test locations. About 6,000 treated and non-treated control posts representing 68 species are under study.

This initial all-inclusive report describes in some detail the materials used, treating methods, chemical retentions, soil and climate at each plot, and reviews the condition of the posts up through the September 1963 inspection. Though most of the posts have been in service for less than five years, some tentative as well as final conclusions can now be made and they are: (1) untreated posts have an average service life of only 1.5 years; (2) treated posts set out at the high elevation plots have fewer failures than matched material placed in the low-land plot; (3) although termite attack may be locally severe, decay fungi cause most of the failures; (4) posts cold-soaked in pentachlorophenol-diesel oil in a vertical position butt down had greater preservative solution absorption than those cold-soaked in a horizontal position; (5) hot-and-cold bath treatments using pentachlorophenol or creosote have, to date, less than 10 percent failures and average service life cannot be accurately predicted, but similar treatments using carbolineum indicate that the service life should be about 15 years or more; (6) posts treated with double diffusion salts applied by complete immersion are more durable than those treated by end-diffusion.

INTRODUCTION

The potential benefits from the use of fence posts properly preserved against decay and termite activity have had little recognition in Puerto Rico. This can be partially attributed to the lack of knowledge concerning the treatability of local species using simple methods that could be readily applied by farmers, stockmen, and others.

The forest lands of Puerto Rico contain numerous species of trees in sizes suitable for fence posts and small poles. Except in a few mangrove areas, these trees are scattered over a large area with little or no concentration of any one species. Therefore, any useful evaluation of treatability and serviceability of local-grown woods must cover a large number of species. Results of such broad evaluations can guide those concerned with forest management in selecting and favoring those species most suitable for preservation treatment.

At the present time, there is a potential market for about one million treated posts per year. A small pressure plant could satisfy this need, but the high initial cost and the long-time effort required to develop consumer acceptance favored the study of low-investment non-pressure methods.

To help introduce good wood preservation practices, a demonstration test plot was first established by the Institute in 1944. Though very limited in scope, this early trial did show that a long service life could be anticipated if a suitable chemical is properly applied by the hot-and-cold bath technique.

Extensive treating and evaluation trials were started in 1959-1960. Posts treated by four non-pressure techniques using five wood preservation chemical combinations are now set out at four test locations. About 6,000 treated and non-treated control posts representing 68 species are under study. Results of some of these treatability and durability studies have been reported by Englerth (7, 8) and Englerth and Goytía (9).

This initial all-inclusive report describes in some detail the materials used, treating methods, chemical retentions, soil and climate at each plot, and reviews the condition of the posts up through the September 1963 inspection.

These continuing wood preservation studies are based on the efforts of several present and former staff members and the authors gratefully acknowledge their contributions. The first hot-and-cold bath tests at the Institute were made in 1944 by J. Marrero and the 1952 cold-soaking trials were established by M. A. Hernández Agosto. The posts in the

1959-1960 installations, which account for most of the tests under review in this report, were treated and set out under the supervision of G. H. Englerth with the assistance of E. Goytía Olmedo. Double diffusion results would have been of limited value without the generous cooperation and analytical work of R. H. Baechler, L. R. Gjovik, and R. F. Reinke of the Forest Products Laboratory (maintained at Madison, Wisconsin by the U.S.D.A. Forest Service in cooperation with the University of Wisconsin.)

POSTS

In the comprehensive 1959 trials, 10 common Puerto Rican species were selected for cold-soaking and hot-and-cold bath treatments using both pentachlorophenol and creosote. Twelve additional species suitable for fence posts were treated with pentachlorophenol by both cold-soaking and hot-and-cold bath. Thirty less common species were treated by cold-soaking only, using pentachlorophenol. Thus, these and the other installations are representative of the available species growing to post size in the forests and plantations of the Commonwealth.

Most of the posts had top diameters of 2 to 3 inches, were 6 feet long, and consisted almost entirely of sapwood. A few posts included an appreciable amount of heartwood, and about 250 posts out of some 6,000 under study had other dimensions.

All of the posts were debarked before treatment and, except for the double-diffusion posts which were treated green, air-seasoned for 3 to 6 months or longer to a moisture content averaging about 18 percent. To minimize insect and fungus attack during seasoning, most of the posts were given a pre-treatment by dipping in a mixture of sodium pentachlorophenate and the gamma isomer of benzene hexachloride. The posts used in the 1952 installation were not given this pre-treatment, and there was severe insect attack in some of the material.

The density of the posts under survey ranged from 17 to 59 pounds per cubic foot, averaging 42 pounds (based on the air-dry weight and volume at approximately 18 percent moisture content.) The very low density woods (less than 25 pounds per cubic foot) are:

achiotillo[1/]	tulipán africano
almácigo	yagrumo hembra
guacimilla	yagrumo macho

1/ Common and scientific names of all species mentioned are listed in the appendix.

Extremely dense woods being evaluated in this study (about 55 pounds per cubic foot and over) are:

ausubo	casuarina
cacao motillo	cieneguillo
ucar	

PRESERVATIVES

Pentachlorophenol

Commercial grade pentachlorophenol concentrate was dissolved in a gas oil carrier. A 10 percent solution (by weight) was used in the cold-soak treatment of posts installed at Cambalache and Toro Negro in 1952; all other "penta" treatments used a 5 percent solution. The properties of the oil carrier were as follows:

Specific gravity (A.P.I. 60°/60°F.)	32.7
Flash point (Pensky-Martens)	173°F.
Viscosity (S.U.S. at 100°F.)	37
Distillation:	
initial boiling point	386°F.
10% recovery at	466°F.
50% " "	524°F.
70% " "	558°F.
90% " "	618°F.
end point	620°F.
total recovery	99.5 pct.

The above analysis is representative of one batch of gas oil (No. 2-D Diesel fuel) used to make up the treating solutions and is believed to be typical of the oil solvent used throughout this study. This oil can be classified as a "Heavy Petroleum Solvent" and conforms to A.W.P.A. Standard P9-62 (1). In order to darken the oil and thus facilitate penetration measurements, 2 percent of No. 6 fuel oil was blended with the gas oil.

Creosote

Commercial grade creosote conforming to A.W.P.A. Standard P1-54 (1) was blended with the oil described above to give a 50-50 (by volume) creosote-gas oil solution.

Carbolineum

The use of this preserving oil was limited to a few of the early studies. Distillation results of a carbolineum

sample from the 1950 treatment were as follows:[1/]

Specific gravity at 38/15.5°C.	1.090
Moisture	0.1 pct.
Distilling up to 210°C.	0 pct.
235°C.	5.1 pct.
270°C.	26.4 pct.
315°C.	48.2 pct.
355°C.	75.5 pct.
Residue above 355°C.	24.0 pct.
Distillation loss	0.5 pct.
Total recovery	100 pct.

Specific gravity of distillation fractions at 38/15.5°C:

235°-315°C.	1.0447
315°-355°C.	1.1154

Generally, the effectiveness of carbolineum as a wood preservative is similar to that of the coal-tar creosotes. (10)

Double diffusion salts

In these treatments two salt combinations were used. Combination FC (fluor copper) consisted of a 4 percent solution of sodium fluoride followed by a 7 percent solution of anhydrous copper sulfate. Combination CAC (copper arsenate chrome) consisted of a 10 percent anhydrous copper sulfate solution in the first stage and a mixture of 6.5 percent anhydrous sodium chromate and 6.5 percent anhydrous sodium arsenate in the second stage. All chemicals were technical grade and dissolved in tap water to the desired concentration.

TREATMENTS

Cold-soaking, hot-and-cold, and double diffusion (steeping and end diffusion) methods were used in the treatments, and since these techniques have been described in detail elsewhere (2, 3, 4, 5, 6), only a brief review of procedure will be given.

Cold soaking

In the 1959 installation, the length, butt and top diameters, heartwood diameters (if present), and air-dry weights of each post were determined prior to treatment. To assure that sufficient seasoning had taken place, the moisture content of the posts was checked with a moisture meter. Batches of

1/ Analyses by R. H. Baechler, Forest Products Laboratory, Madison, Wisconsin.

posts were then clamped in a carrying frame and submerged horizontally for 5 to 7 days in either the 5 percent pentachlorophenol or the 50-50 creosote-gas oil solution. At the end of the treating time, posts were removed from the tank, allowed to drain, and reweighed.

Retention in pounds per cubic foot was determined for each post using the calculated volume and the pounds of preserving solution absorbed. Five to 11 posts of each species representing low, average, and high retentions, were then cross-sectioned at 1-foot intervals along their lengths to determine average side penetration as a percentage of the sapwood radius.

In the 1952 tests, the treating tank was two oil drums welded together and the posts were submerged vertically with the butt ends down in a 10 percent pentachlorophenol solution for a period of 5 days. Post volumes and retentions were determined as described above. No determinations of penetration were made.

Hot-and-cold bath

Posts in the 1959 trials were weighed, measured, and treated in the same chemicals and concentrations as described for the 1959 cold-soak study. Posts were submerged horizontally in the preservative, maintained at about 200°F., for 2 to 15 hours and were then transferred to the cold tank treating solution for an additional 1 to 120 hours. At the end of their respective treating periods, the posts were removed from the cold tank, allowed to drain, and reweighed to determine the pounds of solution absorbed per cubic foot of wood (fig. 1). Schedules were varied according to the treatability of each species in order to obtain, if possible, a retention of about 8 pounds per cubic foot. Penetrations were then determined on sample posts, as described above for the cold-soak method.

These periods in the hot bath may cause a loss in moisture content of 5 to 10 percent, or more. Thus, the retention values given in tables 6, 7, 8 are presumably lower than those actually obtained.

The 1944 and 1950 installations were treated with carbolineum. As in the other hot-and-cold bath treatments, posts were measured to determine volume and weighed before and after treatment to determine retention. Posts were heated in a barrel of preservative solution for 4 to 8 hours at 190-230°F.; then the fire was drawn and posts remained in the cooling preservative for an additional 13 to 18 hours.

Borings were taken from posts treated in 1944 for an estimation of side penetration, and a few posts representative of the 1950 treatments were sectioned for these measurements.

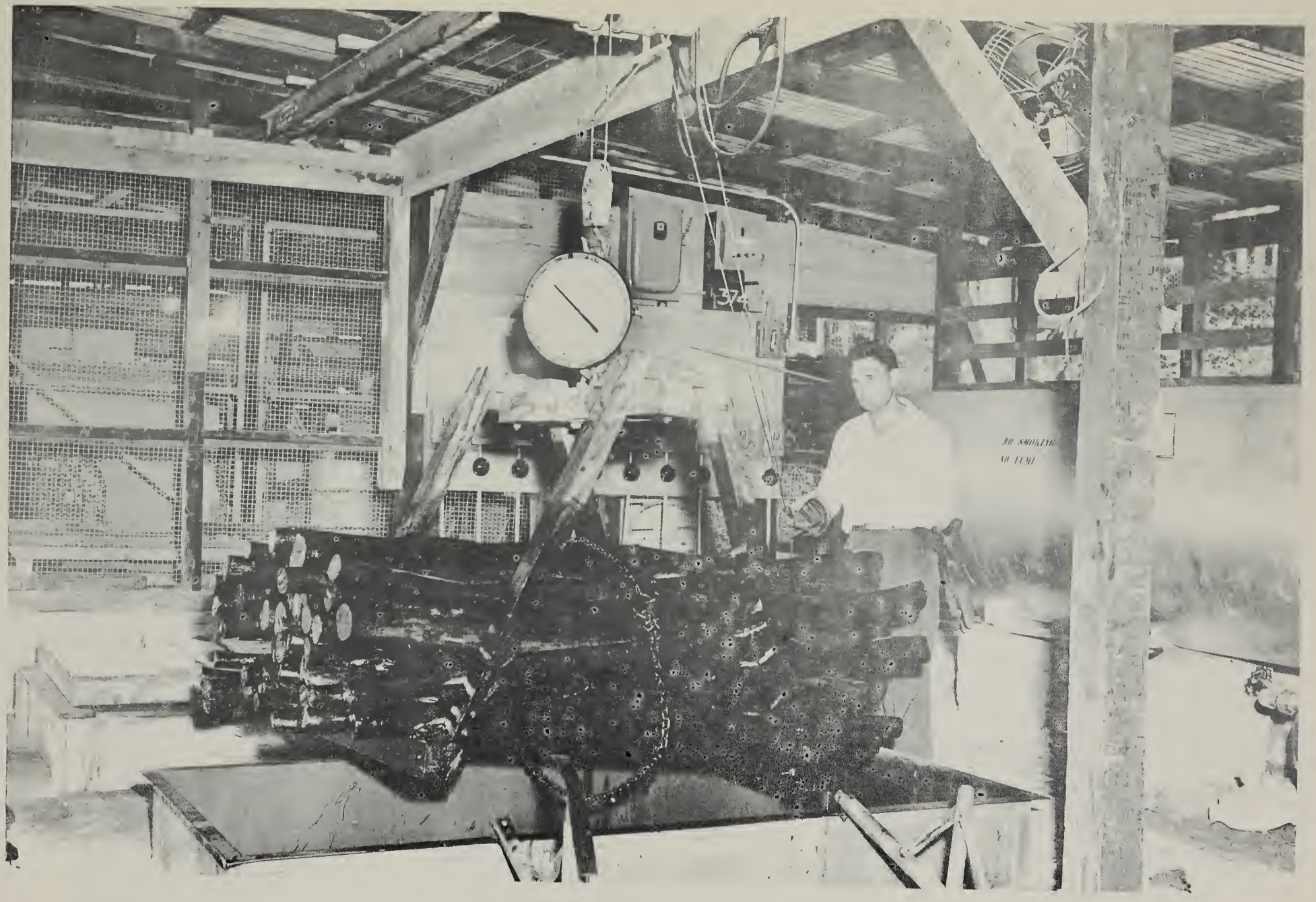

Figure 1.--General view of the experimental hot-and-cold bath treating plant. Posts are being weighed upon removal from the cold tank to determine retention.

Double diffusion

In this method green peeled posts are soaked first in one chemical solution and then in a second solution. The chemicals diffuse into the wood and react with each other to form a toxic compound that is relatively insoluble and resistant to leaching. The posts were treated by two methods: (1) complete immersion in tanks, called the "tank treatment" (T), and (2) end steeping, in which posts are stood upright in a barrel with only the butts in contact with the treating solution, called the "barrel treatment" (B).

For each treating method two chemical combinations were used. In Combination FC the posts were first treated with the sodium fluoride solution for 3 days, then held in the copper sulfate solution for an additional 3 days. Combination CAC consisted of 2 days in copper sulfate solution followed by 2 days in the mixture of sodium arsenate and sodium chromate. Time schedules for some of the species were modified and are so indicated in table 9.

Upon completion of each double diffusion treatment the posts were close-piled for several weeks. Not less than 8 weeks after treatment, posts were sampled to determine penetration and chemical absorption. From tank-treated material a cross section disk was removed from the mid-length of each of 5 sample posts representing each species. A 1/4-inch thick section was then cut from each disk and the five sections were ground together to form a composite sample for determination of chemical retention. Since material from the post ends was not sampled, it is recognized that the results are somewhat lower than the true average, but they do represent retention at the critical ground line.

Five posts from each species treated by the barrel method were sampled for chemical analysis by removing disks 18 inches from the butts and 6 inches from the tops. Composite ground line and composite top samples were then prepared for each species.

Samples were analyzed for the elements known to be present in the preservative solution, copper and fluorine in those posts treated with Combination FC, and copper, arsenic, and chromium in those posts treated with Combination CAC. The results were calculated to the basis of the chemicals initially used with no effort being made to calculate the amounts of the compounds resulting from reactions within the treated wood.

Radial penetrations of copper sulfate in sample disks removed from the middle portion of posts tank-treated with Combination CAC were determined by spraying the disks with a 1 percent aqueous solution of Chrome Azurol S, a red dye which turns deep blue in the presence of a copper compound. Penetrations were classified into four categories from "complete"

to "poor". The results of chemical analyses are given in table 9 along with treating conditions and condition of posts after 3 1/2 years of exposure.

INSTALLATION OF POSTS

The various trials are located at four test sites, the largest installation being the Cambalache plot in the northern coastal area, about 8 miles east of Arecibo (fig. 2). Replicates of the more important species were placed in the high-elevation Guavate plot located 23 miles due south of San Juan. The species commonly found in mountain terrain and treated with 10 percent pentachlorophenol are located at Toro Negro, 14 miles northeast of Ponce; other post species growing at low elevations and receiving the same treatment are located on a clay soil in the Cambalache area -- seven species are replicated at the two sites. Three species treated with carbolineum are also replicated at Toro Negro and Cambalache. Several casuarina posts treated with carbolineum have been set out at El Verde, 4 miles south of Río Grande. With few exceptions, untreated posts of each species were installed at each test site.

Figure 2.--The main Cambalache plot showing layout of the test posts.

Data concerning soil, geology, and climatic conditions, believed to be representative of these sites, are given in table 1. Most of the posts at Cambalache are set in a sandy clay loam, and the soils at all of the high-elevation plots are heavy clays.

Almost all of the posts were set out in randomized blocks and were generally spaced 36 inches within and between rows. The 6-foot posts were installed with their butts 18 inches in the ground, and post stubs were set 12 inches in the soil.

For the 1959-1960 installations there are generally 20 replications per species per treatment at each site except that posts treated by double diffusion using the barrel method have 10 replicates or less. Replications of posts treated with 10 percent pentachlorophenol and carbolineum are variable, ranging from only 2 for some species up to 12 for others.

All posts are identifiable by coded metal tags, and detail maps showing plot locations and post locations within plots were made for reference.

INSPECTION

Posts are inspected annually to determine current serviceability by firmly pushing the tops. If the post breaks, cause of failure is determined, i.e. fungi or termite activity or both. Though not recorded here, serviceable posts are also inspected to determine whether or not they are free of decay or termite attack. If damage due to these agencies is present, the estimated degree of degradation is noted.

The average service life of posts receiving any particular treatment is then determined from mortality curves developed by MacLean (11) and is defined as that period when 60 percent of the posts have failed. Predictions of service life are calculated only for those treatments having 10 percent or more failures, since less failure provides an unreliable basis for use of the curves. These predictions may be modified in future reports, but the data for average service life in tables 2 - 9 for post treatments having 60 percent or more failures are already final.

RESULTS TO DATE

Data on treating conditions, chemical retentions, and serviceability are presented in tables 2 - 9. A discussion of these results is given below:

Untreated control posts (table 2)

Of 1,421 untreated control posts in the ground from 3.5 to 4.5 years, 6 percent are still serviceable, 58 percent have been destroyed by decay, 35 percent have failed because of combined decay and termite attack, and 1 percent has been destroyed by termite attack.

Average service life of all species is 1.5 years (in 1.5 years we can expect 60 percent failure), but individual species vary from 0.4 to 4.4 years. The longer life of some of the species, i.e. mangle prieto, capá blanco, and úcar can be attributed to the presence of a large volume of durable heartwood.

For the 10 species common to both sites, average service life at Cambalache is 1.4 years and at Guavate 1.5 years. A comparison of percentage failures after only one year of service life showed that there have been 42 percent removals at Cambalache and 31 percent at Guavate. Though it appears that conditions for rot in non-treated posts are slightly more favorable in the low-land plot, these differences are not statistically significant.

Cold-soak in 5 percent pentachlorophenol in gas oil (table 3)

The 5-day cold soak resulted in retentions that varied with species from 0.8 to 10.1 pounds per cubic foot, and the average for all species combined is 3.8 pounds per cubic foot. Side penetration also varied considerably, ranging from 5 to 100 percent of the sapwood radius.

The following species can be classified as having moderately good retention and penetration when treated by this cold-soak method (retention of at least 4 pounds per cubic foot and over 50 percent sapwood penetration):

achiotillo	caimitillo
almácigo	casuarina
cacao motillo	mantequero
caimitillo verde	sabinón
yagrumo hembra	

Of 1,234 posts installed at both plots in 1959, 69 percent are still serviceable after about 4.5 years, 23 percent have been destroyed by decay, 7 percent by fungi and termite attack, and 1 percent by termite activity.

Of the 53 species located at Cambalache 40 have sufficient failures for prediction of service life. This ranges from 3 to 7 years, averaging 5 years. For the 10 species located at

both sites, 18 percent of the posts failed at Cambalache but only 4 percent failed at Guavate. Average retention of the two groups was almost identical, 3.9 and 4.1 pounds per cubic foot respectively.

Achiotillo, cacao motillo, caimitillo, caimitillo verde, casuarina, and sabinón are not only the few species most receptive to treatment by this cold-soak method, but field results to date also indicate that they will have an average service life substantially longer than 7 years.

Some species with poor to fair retention and penetration are also showing good service, partially because of the presence of durable heartwood. Nevertheless, these as well as the other species under evaluation, except for the six listed above, have questionable benefits from this treatment and more effective impregnation techniques should be considered.

Achiotillo and sabinón have preservative absorptions (8.4 and 10.1 pounds per cubic foot respectively) that are higher than those usually required for fence posts, i.e. 6 pounds, and a shorter cold-soaking period could minimize excessive chemical absorption and advantageously reduce the treating cost.

Cold-soak in 50-50 creosote-gas oil (table 4)

The 5- to 7-day cold soak in the mixture of creosote and gas oil resulted in species retentions of 1.6 to 5.3 pounds per cubic foot, averaging 4.0 pounds. Side penetration varied from 11 to 60 percent of the sapwood radius.

Of 397 posts installed at both plots in April 1959, 92 percent are still serviceable after 4.5 years, 7 percent have been destroyed by decay, and 1 percent has been destroyed by decay and termite attack combined. No posts were lost due to termite attack alone.

Failures at Cambalache have amounted to 12 percent, but at Guavate only 4 percent have been destroyed. Only 4 out of the 10 species have sufficient failures for prediction of service life, and this ranges from 5 to 7 years.

Casuarina, guamá, and rabo de ratón have moderately good retentions and penetrations and average service life should be considerably more than 7 years. Camasey blanco, guaba, hoja menuda, and pomarrosa are showing early failures at Cambalache due to either inadequate absorption or poor penetration and these species should be avoided for this type of cold-soak preservation treatment.

For the same species given a cold-soak treatment with 5 percent pentachlorophenol and 50-50 creosote, the preservative absorptions and penetrations are almost identical and the number of failures is also approximately the same, 8 and 11 percent respectively.

Cold-soak in 10 percent pentachlorophenol in gas oil (table 5)

These posts were treated butt down in the preservative solution. Some of the species had light to severe wood borer attack prior to the treatment. Test posts were 4 feet long with a top diameter of about 3 inches.

At Cambalache, species retentions ranged from 2.1 to 15.1 pounds per cubic foot, averaging 5.9. Of those set at Toro Negro, retentions varied from 5.0 to 9.7 pounds per cubic foot and averaged 6.8 pounds per cubic foot. No penetration data are available for these tests.

Of 122 posts installed at Cambalache, 43 percent are still serviceable after 11.5 years of ground contact, 56 percent have been destroyed by decay fungi, and only 1 percent has been lost due to combined decay and termite attack. Of 80 posts installed at Toro Negro, 93 percent are serviceable, only 7 percent have been destroyed by decay fungi. There are no failures attributable partially or wholly to termite attack.

For the same seven species located at both plots, at Cambalache there have been 52 percent failures, and only 12 percent at Toro Negro. Average preservative retentions are 5.9 and 6.7 pounds per cubic foot respectively.

For all the species at Cambalache, service life estimates range from 5 to 18 years, averaging 11 years. Posts at Toro Negro should have an average service life of at least 15 years, but there are as yet, too few failures upon which to base an accurate prediction.

Of the eight replicated species located at the Cambalache plots now having a predictable service life, one group treated with 5 percent pentachlorophenol and the other with 10 percent pentachlorophenol, those treated with the former concentration have an average service life of about 5 years while those treated with the latter concentration have an estimated service life of 11 years. It should be noted that average preservative retentions are respectively 4.0 and 6.6 pounds of solution per cubic foot or more appropriately 0.20 and 0.66 pound of dry chemical per cubic foot.

Many of the posts treated with 10 percent pentachlorophenol had mild to severe insect attack before treatment and

this could account for the higher solution absorption. Individual posts of those species that had varying degrees of insect damage prior to treatment generally show higher preservative absorptions in the more severely attacked posts.

A large part of the higher retentions in the 10 percent treatment, however, can be attributed to the method of cold-soaking. If we compare the retention of those six species treated with 10 percent pentachlorophenol, that were free of insect attack prior to treatment, with the same species preserved with 5 percent pentachlorophenol, we find that the average absorptions are respectively 6.2 and 3.8 pounds per cubic foot. The posts treated with the 10 percent solution were submerged butt down in a relatively deep tank and greater hydrostatic pressure could force a larger quantity of preservative into the wood than would be absorbed if submerged in a horizontal position. The use of this technique to increase absorption has been described by Walters (12), Walters and Meek (13), and Blew (5).

Except for uvilla and tortugo amarillo, the serviceability of all the species is most satisfactory and in many cases excellent. This vertical cold-soak technique appears to be well adapted to a wide choice of species. It must be realized, however, that the pentachlorophenol consumption is about three times greater than for the conventional horizontal cold-soak treatment described above.

Hot-and-cold bath, 5 percent pentachlorophenol in gas oil (table 6)

Retention by species ranged from 3.9 to 25.0 pounds per cubic foot, averaging 9.5 pounds. Side penetration is generally good, varying from 42 to 100 percent of the sapwood radius.

After 4.5 years of service, only 4 out of 630 posts installed at Cambalache and Guavate have been destroyed by decay fungi. Average service life cannot, as yet be predicted, but these very few failures and other results to be discussed below do suggest that these posts will be serviceable for at least 15 years.

Time in the hot-and-cold baths was varied considerably according to the treatability of each species and in many cases absorptions are excessive. Most of these schedules cannot be recommended for a commercial operation and more feasible cycles are now being developed.

Hot-and-cold bath, 50-50 creosote-gas oil solution (table 7)

As for the same method using pentachlorophenol, widely different time schedules were adopted. Species retentions varied from 5.4 to 13.1 pounds per cubic foot, averaging 8.5 pounds per cubic foot. Side penetrations ranged from 59 to 100 percent of the sapwood radius.

All 394 posts installed at Cambalache and Guavate are still serviceable after 4.5 years in the ground. Again this indicates that average service life should be 15 years or more.

Hot-and-cold bath, carbolineum (table 8)

Posts treated with carbolineum represent the oldest test installation under review in this report, and though the number of posts is very limited, results to date permit some definite conclusions. Posts installed in 1950 were 6 feet long and had top diameters that ranged from 3 to 5 inches; those set out in 1944 were 3- to 4-foot long stubs with top diameters of 5 to 6 inches.

Retention for the three species treated in 1950 ranged from 5 to 9 pounds per cubic foot with an irregular side penetration. The casuarina posts installed in 1944 have excessively high retentions, averaging 20 pounds per cubic foot, with a side penetration of about 1 inch or 30 percent of the sapwood radius.

There are no failures in the 1950 installations. Of six casuarina posts installed in 1944, there has been one failure, which indicates an average predicted service life of 26 years.

The excellent record of the eucalyptus and caimitillo posts strongly suggests that we can anticipate similar results from most of the species treated with pentachlorophenol or creosote using the hot-and-cold bath technique, and is a basis for our assumption that these posts should have an average service life of at least 15 years.

Double diffusion (table 9)

A. Tank treatments (T).--Dry salt retentions of Combination FC (sodium fluoride followed by copper sulfate) varied from 0.07 pound per cubic foot for mangle blanco to 0.60 pound per cubic foot for the eucalypt. Average retention for all species is 0.34 pound per cubic foot. Total salt concentration used in Combination CAC (copper sulfate followed by a mixture of sodium chromate and sodium arsenate) is about double that in Combination FC and retentions ranged from 0.28 pound per cubic foot for caimitillo to 1.44 pounds per cubic foot for almendra, averaging 0.76 pound.

Of 670 posts treated by Combination FC, there have been, after 3.5 years of service, 8 percent failures. Of 664 posts treated with the Combination CAC salts, there have been 4 percent failures. Bamboo accounted for 50 percent of these removals.

Penetration data are available only for posts treated with the Combination CAC salts, and 93 percent of the failures were in those species having fair or poor penetration.

For the species located at both Cambalache and Guavate and treated with Combinations FC and CAC, there have been 22 percent removals out of 274 posts installed at Cambalache; at Guavate only 12 percent of 275 posts have failed.

B. Barrel or end diffusion treatments (B).--Ground line retentions of posts treated with Combination FC varied with species from 0.13 to 0.99 pound per cubic foot, averaging 0.66 pound. Posts treated with Combination CAC have dry salt retentions varying from 0.69 to 4.33 pounds per cubic foot averaging 1.44 pounds.

Movement of the chemicals to the top of the posts by end diffusion was negligible. In almost all cases, the absorption in the tops is considerably less than 0.1 pound per cubic foot. Though not shown in table 9, a large number of the posts treated by the barrel method were classified non-serviceable due to severe decay in the tops and not because of failure at the ground line.

Of the 252 posts treated with Combination FC, 26 percent have failed after 3.5 years of service, compared to 12 percent failures in those 276 posts treated with Combination CAC.

Optimum retentions of these water-borne preservatives, as applied to tropical hardwoods, are still not known. Minimum requirements should be at least those specified for the various salt combinations used to treat coniferous post species in a more temperate climate, i.e. 0.5 to 1.0 pound of dry salt per cubic foot (1). The tank treatment using the copper arsenate chromate combination appears to be most suitable as only four species (caimitillo, cassia de Siam, guamá, and maría) out of the 30 under evaluation have less than minimal retentions. Species that show particular promise are those having good sapwood penetration, as well, and they are:

achiotillo	laurel geo
almácigo	teca
almendra	tulipán africano
camasey blanco	verde seco
eucalipto (robusta)	yagrumo hembra
guaba	yagrumo macho

This is supported, so far, by the service records as there are only 2 failures in this group out of the 270 posts installed.

CONCLUSIONS

Although most of the posts have been in service less than 5 years, several tentative conclusions may now be drawn:

1. Whether established in a coastal or mountain area, average service life of untreated posts is only 1.5 years, individual species varying from 0.4 to 4.4 years. The longer life of some of the species can be attributed to the presence of a large volume of durable heartwood.

2. Although termite attack may be locally severe, decay fungi cause most of the failures.

3. In all preservation treatments having sufficient removals upon which to base an estimate of average service life, posts established at the several high elevation plots have fewer failures than matched material placed in the low-land plot.

4. Of the 53 species located at Cambalache and treated by cold-soaking for 5 days in 5 percent pentachlorophenol dissolved in gas oil, 40 have sufficient failures for predicting a service life of 3 to 7 years, averaging 5 years. Achiotillo, cacao motillo, caimitillo, caimitillo verde, casuarina, and sabinón are the few species most receptive to this treatment and field results, to date, indicate that they will have an average service life substantially longer than 7 years.

5. For the same species given a 5-day cold-soak treatment with 5 percent pentachlorophenol and a similar treatment with 50-50 creosote-gas oil, the preservative absorptions and penetrations are almost identical and the number of failures is also approximately the same.

6. Posts treated with a 10 percent concentration of pentachlorophenol in gas oil by cold-soaking in a vertical position butt down for 5 days have, with the exception of uvilla and tortugo amarillo, an estimated average life of about 12 years at Cambalache. A comparison of matched species shows that vertical cold-soaking, using a 10 percent preservative concentration, increases chemical absorption threefold over that obtainable with posts treated in a horizontal position using a 5 percent solution.

7. Of 1,882 posts treated by double diffusion, regardless of method or chemical combination, 90 percent are still

serviceable after 3.5 years in the ground. Most of the failures were posts with only butts treated and little or no chemical absorption in the tops, bamboo being especially vulnerable. The most promising double diffusion technique is the tank method using a 2-day soak in 10 percent copper sulfate followed by a 2-day soak in a mixture of 6.5 percent sodium arsenate and 6.5 percent sodium chromate. Species that are particularly responsive to this treatment are:

achiotillo	laurel geo
almácigo	teca
almendra	tulipán africano
camasey blanco	verde seco
eucalipto (robusta)	yagrumo hembra
guaba	yagrumo macho

Table 1.--Description of test plot sites

Item	Location			
	Cambalache	Guavate	Toro Negro	El Verde
Elevation (ft.)	100	2100	2900	1120
Soil	clay to sandy clay loam pH 5.9	clay pH 5.3	clay pH 5.1	clay pH 5.4
Geology	deposited from coastal materials	residual from volcanic rock	residual from volcanic rock	residual from volcanic rock
Temperature (°F.)				
mean coldest month	74.0	69.3	65.8	69.3
mean hottest month	80.4	75.9	72.1	76.1
mean annual	77.6	73.1	69.3	73.1
Rainfall (in.)				
Sept.-Nov.	16.0	17.3	37.6	29.4
Dec.-Feb.	16.4	11.2	13.4	13.5
Mar.-May	11.6	14.4	24.6	24.1
June-Aug.	12.5	39.7	23.8	32.0
mean annual	56.5	82.6	99.4	99.0

Table 2.--Condition of untreated control posts installed in the Cambalache (CA) and Guavate (GU) test plots, Puerto Rico after about 4 1/2 years of service. Posts installed in April 1959

Species	Location	Posts in test	Condition of posts, Sept. 1963				Total removed		Average life [1]
			Serviceable	Removed because of					
				Decay	Decay & termites	Termites			
		No.	No.	No.	No.	No.	No.	Pct.	Yr.
Achiotillo	CA	19	--	9	10	--	19	100	.9
Aguacatillo	CA	20	--	18	2	--	20	100	1.4
Almácigo	CA	20	--	18	2	--	20	100	.4
Almendra	CA	20	--	13	7	--	20	100	1.3
Ausubo	CA	20	--	8	11	1	20	100	1.9
Bambú [2]	CA	20	--	17	3	--	20	100	1.4
"	GU	17	1	15	1	--	16	94	2.1
Cacao motillo	CA	20	--	6	14	--	20	100	1.4
Caimitillo verde	CA	20	--	15	5	--	20	100	1.8
Camasey jusillo	CA	19	--	12	7	--	19	100	3.3
Camasey blanco	CA	20	--	17	3	--	20	100	1.3
" "	GU	20	1	19	--	--	19	95	1.2
Caoba [2]	CA	20	3	10	7	--	17	85	2.1
Capá blanco	CA	17	7	5	5	--	10	59	4.4
Caracolillo	CA	19	--	12	7	--	19	100	1.7
Cassia	CA	20	--	14	6	--	20	100	1.0
Casuarina	CA	20	--	6	14	--	20	100	1.0
"	GU	20	--	19	1	--	20	100	1.5
Cieneguillo	CA	20	--	13	7	--	20	100	1.9
Cucubano	CA	20	--	10	10	--	20	100	1.2
Espino rubial	CA	19	--	9	10	--	19	100	.9
Eucalipto (robusta)	CA	20	--	6	13	1	20	100	1.4
Granadillo	CA	20	1	9	10	--	19	95	1.4
Guaba	CA	20	--	11	9	--	20	100	1.3
"	GU	18	--	18	--	--	18	100	1.4
Guamá	CA	19	--	11	8	--	19	100	1.5
"	GU	20	--	19	1	--	20	100	1.6
Guaraguao	CA	20	--	9	11	--	20	100	1.1
Hoja menuda	CA	20	--	10	10	--	20	100	1.4
" "	GU	20	--	18	2	--	20	100	1.8
Hueso blanco	CA	20	--	12	8	--	20	100	1.4
Jagüey "	CA	20	--	13	7	--	20	100	1.1
Laurel avispillo	CA	20	--	10	10	--	20	100	.9
Laurel geo	CA	18	--	4	14	--	18	100	1.1
" "	GU	19	--	19	--	--	19	100	1.2
Mangle blanco	CA	20	--	3	13	4	20	100	1.0
" "	GU	20	--	18	2	--	20	100	1.3
Mangle colorado	CA	20	--	12	8	--	20	100	1.2
Mangle prieto	CA	20	7	5	8	--	13	65	3.6
Mantequero	CA	19	--	3	16	--	19	100	.9
Manzanillo	CA	19	--	2	16	1	19	100	.9
María	CA	20	--	7	13	--	20	100	1.2
Maricao	CA	19	--	15	4	--	19	100	1.4
Masa	CA	20	--	6	13	1	20	100	1.2
Mesa	CA	20	--	11	9	--	20	100	1.4
Moca	CA	20	--	13	7	--	20	100	1.2
Moral	CA	20	--	11	9	--	20	100	.8
Muñeco	CA	17	--	8	9	--	17	100	.9
Negra lora	CA	20	--	10	10	--	20	100	1.8
Palo de gallina	CA	20	--	15	5	--	20	100	.8
Palo de matos	CA	20	--	7	13	--	20	100	1.0
Péndula	CA	14	--	7	7	--	14	100	1.2
Pomarrosa	CA	18	--	3	14	1	18	100	1.1
"	GU	20	--	19	1	--	20	100	1.2
Rabo de ratón	CA	20	--	12	8	--	20	100	.8
" " "	GU	20	--	20	--	--	20	100	.7
Retama [2]	CA	20	--	17	2	1	20	100	1.7
Roble	CA	20	1	15	4	--	19	95	3.0
"	GU	20	2	16	2	--	18	90	2.8
Sabinón	CA	20	--	6	14	--	20	100	1.2
Tabonuco	CA	18	--	11	7	--	18	100	1.2
Teca	CA	20	1	10	9	--	19	95	1.4
Tulipán africano	CA	20	--	17	3	--	20	100	.9
Ucar [2]	CA	55	34	20	1	--	21	38	4.0
Uvilla	CA	20	--	11	8	1	20	100	1.4
Verde seco [2]	CA	21	4	16	1	--	17	81	2.1
Yagrumo hembra	CA	17	--	12	5	--	17	100	.6
Yagrumo macho	CA	20	--	10	10	--	20	100	.8
Zarcilla [2]	CA	60	26	29	4	1	34	57	3.6

1/ Average life based on that period when 60 percent of the posts have failed.

2/ Posts in service 3 1/2 years at time of last inspection.

Table 3.--Condition of round posts treated by cold soaking for 5 days in 5% pentachlorophenol dissolved in diesel oil after about 4 1/2 years of service. Cambalache (CA) and Guavate (GU) test plots, Puerto Rico. Posts installed in April 1959

Species	Location	Posts in test	Retention of preservative			Average side penetration of sapwood radius		Condition of posts, Sept. 1963				Total removed		Average life 1/
			Min.	Max.	Av.			Serviceable	Removed because of					
									Decay	Decay & termites	Termites			
		No.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	Pct.	Yr.
Achiotillo	CA	19	6.2	13.1	8.4	1.63	100	19	--	--	--	--	--	--
Aguacatillo	CA	20	.6	3.2	1.6	.10	7	8	11	1	--	12	60	4.4
Almácigo	CA	18	4.3	8.9	6.1	1.07	85	5	13	--	--	13	70	4.2
Almendra	CA	18	1.6	3.2	2.2	.33	34	9	7	2	--	9	50	4.7
Ausubo	CA	20	1.9	3.9	2.6	.52	36	13	2	4	1	7	35	5.2
Bambú	CA	20						12	8	--	--	8	40	5.0
Cacao motillo	CA	20	3.8	8.1	5.3	1.35	92	19	1	--	--	1	5	--
Caimitillo	CA	20	5.1	9.3	7.4	1.13	79	20	--	--	--	--	--	--
Caimitillo verde	CA	20	--	--	5.7	.64	46	20	--	--	--	--	--	--
Camasey blanco	CA	20	1.2	3.6	2.3	.10	8	16	4	--	--	4	20	5.9
" "	GU	19	1.6	3.0	2.4	.10	8	18	1	--	--	1	5	--
Camasey jusillo	CA	20	1.4	3.2	2.1	.10	8	18	1	1	--	2	10	6.8
Capá blanco	CA	20	1.7	6.4	2.6	.31	26	20	--	--	--	--	--	--
Caracolillo	CA	19	1.3	2.9	2.1	.42	28	16	3	--	--	3	16	6.3
Cassia de Siam	CA	20	3.1	6.6	4.8	.62	42	16	3	1	--	4	20	5.9
Casuarina	CA	20	3.9	8.4	5.6	.93	72	19	1	--	--	1	5	--
"	GU	20	3.7	7.5	5.4	.93	72	20	--	--	--	--	--	--
Cieneguillo	CA	20	.5	2.0	.8	.15	11	13	3	3	1	7	35	5.2
Cucubano	CA	20	1.8	3.6	2.5	.17	13	18	2	--	--	2	10	6.8
Espino rubial	CA	19	2.1	3.1	2.6	.19	17	--	15	4	--	19	100	2.7
Eucalipto (robusta)	CA	20	.9	3.9	2.1	.17	22	10	8	2	--	10	50	4.7
Granadillo	CA	19	2.1	5.9	3.1	.41	46	18	1	--	--	1	5	--
Guaba	CA	20	2.5	5.5	3.9	.25	20	17	3	--	--	3	15	6.3
"	GU	20	2.7	5.4	4.1	.25	20	20	--	--	--	--	--	--
Guamá	CA	20	2.0	6.9	3.4	.34	31	17	3	--	--	3	15	6.3
"	GU	20	1.8	6.7	3.6	.34	31	20	--	--	--	--	--	--
Guaraguao	CA	20	2.3	4.8	3.4	.97	79	13	7	--	--	7	35	5.2
Hoja menuda	CA	20	1.4	3.9	2.6	.16	13	16	2	2	--	4	20	5.9
" "	GU	20	1.8	3.5	2.7	.16	13	20	--	--	--	--	--	--
Hueso blanco	CA	20	1.1	2.5	1.9	.59	45	11	4	5	--	9	45	4.9
Jagüey	CA	20	1.9	5.6	2.6	.41	28	3	14	3	--	17	85	3.7
Laurel avispillo	CA	19	1.5	3.0	2.2	.53	41	2	12	4	1	17	89	3.6
Laurel geo	CA	20	3.0	7.4	5.0	.34	27	13	6	1	--	7	35	5.2
Mangle blanco	CA	20	1.9	6.8	3.4	.59	52	20	--	--	--	--	--	--
" "	GU	20	2.3	5.3	3.4	.59	52	18	1	1	--	2	10	6.8
Mangle colorado	CA	19	2.2	3.5	3.0	.73	60	8	7	3	1	11	58	4.5
Mangle prieto	CA	19	1.7	4.0	2.5	.48	44	18	1	--	--	1	5	--
Mantequero	CA	20	4.1	9.7	6.3	.70	50	6	9	5	--	14	70	4.2
Manzanillo	CA	18	5.1	8.1	6.2	.52	33	16	1	1	--	2	11	6.8
María	CA	20	2.2	6.4	4.1	.34	24	11	7	2	--	9	45	4.9
Maricao	CA	20	1.9	4.2	2.8	.32	22	15	2	3	--	5	25	5.7
Masa	CA	20	1.0	2.6	1.8	.20	16	--	3	12	5	20	100	3.4
Moca	CA	20	2.8	4.8	3.8	.89	69	20	--	--	--	--	--	--
Moral	CA	17	2.5	6.0	3.5	.29	28	6	7	3	1	11	65	4.3
Muñeco	CA	20	3.3	7.0	4.9	.52	40	10	10	--	--	10	50	4.7
Negra lora	CA	19	1.4	4.1	2.6	.06	5	11	8	--	--	8	40	5.0
Palo de gallina	CA	20	2.7	5.4	4.0	.14	10	9	9	1	1	11	55	4.6
Palo de matos	CA	20	2.2	5.4	3.1	.28	23	15	3	2	--	5	25	5.7
" " "	GU	20	3.7	7.1	5.3	.28	23	18	2	--	--	2	10	6.8
Péndula	CA	19	1.1	2.9	1.9	.20	14	18	1	--	--	1	5	--
Pomarrosa	CA	20	3.2	6.7	4.9	.31	22	14	4	2	--	6	30	5.5
"	GU	20	2.7	7.1	4.9	.31	22	20	--	--	--	--	--	--
Rabo de ratón	CA	20	2.8	6.2	4.6	.39	32	13	5	2	--	7	35	5.2
" " "	GU	19	3.2	7.0	4.4	.39	32	17	2	--	--	2	10	6.8
Roble	CA	20	3.3	5.7	4.3	.53	37	19	1	--	--	1	5	--
"	GU	20	3.7	5.9	4.7	.53	37	19	1	--	--	1	5	--
Sabinón	CA	20	6.7	13.6	10.1	.91	69	20	--	--	--	--	--	--
Tabonuco	CA	19	1.4	3.5	2.0	.12	8	3	7	7	2	16	84	3.8
Teca	CA	19	1.0	2.6	1.6	.50	51	10	7	1	1	9	47	4.8
Tulipán africano	CA	19	3.1	6.2	4.4	.19	17	9	10	--	--	10	53	4.6
Uvilla	CA	20	2.1	5.4	3.5	.40	29	10	10	--	--	10	50	4.7
Yagrumo hembra	CA	19	2.1	6.1	4.1	.65	50	5	13	1	--	14	73	4.1
Yagrumo macho	CA	18	2.8	5.5	3.6	.81	56	1	14	3	--	17	94	3.4

1/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 4.--Condition of round posts treated by cold soaking in 50% creosote - 50% diesel oil after about 4 1/2 years of service. Cambalache (CA) and Guavate (GU) test plots, Puerto Rico. Treated posts installed in April 1959

Species	Location	Posts in test	Treating time	Retention of preservative			Average side penetration of sapwood radius		Condition of posts, Sept. 1963				Total removed		Average life 1/
				Min.	Max.	Av.			Serviceable	Removed because of					
										Decay	Decay & termites	Termites			
		No.	Hrs.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	Pct.	Yr.
Camasey blanco	CA	20	120	.6	2.7	1.6	.14	11	14	6	--	--	6	30	5.5
" "	GU	20	120	.8	2.6	1.8	.14	11	15	5	--	--	5	25	5.7
Casuarina	CA	20	120	2.4	8.8	5.3	.81	55	19	1	--	--	1	5	--
"	GU	20	120	3.6	6.9	5.1	.81	55	20	--	--	--	--	--	--
Guaba	CA	20	168	2.4	6.3	4.2	.12	13	18	2	--	--	2	10	6.8
"	GU	19	168	3.4	5.6	4.2	.12	13	19	--	--	--	--	--	--
Guamá	CA	20	168	2.8	5.8	4.2	.71	53	20	--	--	--	--	--	--
"	GU	20	168	2.4	5.7	3.6	.71	53	20	--	--	--	--	--	--
Hoja menuda	CA	20	120	1.7	3.7	2.8	.14	11	10	8	2	--	10	50	4.6
" "	GU	20	120	1.9	4.0	2.8	.14	11	19	--	1	--	1	5	--
Laurel geo	CA	20	120	3.9	7.1	5.1	.22	16	19	1	--	--	1	5	--
" "	GU	19	120	3.6	7.8	5.3	.22	16	19	--	--	--	--	--	--
Mangle blanco	CA	20	120	1.8	5.3	3.2	.39	60	19	1	--	--	1	5	--
" "	GU	20	120	1.9	6.6	3.0	.39	60	20	--	--	--	--	--	--
Pomarrosa	CA	20	120	3.1	5.6	4.6	.31	22	16	1	3	--	4	20	5.9
"	GU	20	120	1.8	6.6	4.6	.31	22	19	1	--	--	1	5	--
Rabo de ratón	CA	20	120	4.0	6.1	4.9	.63	50	20	--	--	--	--	--	--
" " "	GU	19	120	4.1	6.9	5.4	.63	50	18	1	--	--	1	5	--
Roble	CA	20	120	3.0	6.2	4.5	.40	29	20	--	--	--	--	--	--
"	GU	20	120	3.0	6.1	4.6	.40	29	20	--	--	--	--	--	--

1/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 5.--Condition of round posts treated by cold soaking for 5 days in 10% pentachlorophenol dissolved in diesel oil after about 11 1/2 years in service. Cambalache and Toro Negro test plots, Puerto Rico. Posts installed April 1952

Species	Posts in test	Retention of preservative			Insect attack prior to treatment [1]	Condition of posts, Sept. 1963				Total removed		Average life [2]
		Min.	Max.	Av.		Serviceable	Removed because of					
							Decay	Decay & termites	Termites			
	No.	Lb. per cu.ft.	Lb.per cu.ft	Lb.per cu.ft		No.	No.	No.	No.	No.	Pct.	Yr.
CAMBALACHE TEST PLOT												
Abeyuelo	3	2.7	4.4	3.5	0	2	1	--	--	1	33	13.8
Acasia amarilla	9	4.6	12.0	7.3	L-H	5	4	--	--	4	45	12.8
Almácigo	8	12.9	18.7	15.1	0	1	7	--	--	7	87	8.9
Caimitillo de perro	10	2.1	6.2	4.6	0	4	6	--	--	6	60	11.5
Camasey de felpa	3	1.8	2.6	2.1	0	1	2	--	--	2	67	9.5
Cassia de Siam	10	3.3	7.2	4.3	0-H	5	5	--	--	5	50	12.1
Guácima	10	5.2	11.1	7.9	0	3	7	--	--	7	70	10.9
Guamá	4	4.2	9.1	6.2	0-H	1	3	--	--	3	75	10.5
Jagüey	4	3.8	4.2	4.0	0-L	2	1	1	--	2	50	12.1
Mangle blanco	7	9.0	13.7	12.2	M-H	3	4	--	--	4	57	11.7
Mangle prieto	9	2.6	4.2	3.4	0	3	6	--	--	6	67	11.0
Moca	5	3.0	8.0	6.2	0-H	2	3	--	--	3	60	11.5
Moral	3	5.3	8.3	6.9	0	1	2	--	--	2	67	11.0
Péndula	3	1.4	3.3	2.4	0	1	2	--	--	2	67	11.0
Rabo de ratón	5	3.3	6.0	4.4	0	3	2	--	--	2	40	13.2
Roble	5	4.0	6.0	5.0	0	3	2	--	--	2	40	13.2
Tabloncillo	3	3.3	6.2	4.6	0	1	2	--	--	2	67	9.5
Tortugo amarillo	3	2.9	4.2	3.8	0	--	3	--	--	3	100	5.4
Uvilla	3	2.0	3.6	2.9	0-H	--	3	--	--	3	100	6.0
Yagrumo macho	5	7.0	10.2	8.7	0-H	3	2	--	--	2	40	13.2
Zarcilla	10	7.0	12.7	8.9	H	9	1	--	--	1	10	17.7
TORO NEGRO TEST PLOT												
Cacao motillo	3	7.0	8.6	7.9	L-M	3	--	--	--	--	--	--
Caimitillo	10	3.7	9.3	7.2	0	10	--	--	--	--	--	--
Caimitillo verde	3	6.9	7.7	7.3	0	3	--	--	--	--	--	--
Eucalipto (patentinervis)	3	6.8	7.7	7.2	0	3	--	--	--	--	--	--
Eucalipto (robusta)	3	5.4	8.2	6.5	0	3	--	--	--	--	--	--
Guacimilla	9	5.3	8.7	6.7	0-L	8	1	--	--	1	11	17.5
Guaba	10	3.8	11.3	6.0	0-H	9	1	--	--	1	10	17.7
Guamá	5	3.4	10.8	7.6	L-H	5	--	--	--	--	--	--
Jagüey	4	4.2	6.7	5.6	M-H	3	1	--	--	1	25	14.8
María	4	6.8	7.2	7.0	0	4	--	--	--	--	--	--
Moca	5	4.1	7.0	5.7	0-H	4	1	--	--	1	20	15.4
Moral	5	6.0	9.5	8.0	0-M	4	1	--	--	1	20	15.4
Palo de matos	10	3.9	8.2	5.4	0-M	10	--	--	--	--	--	--
Rabo de ratón	6	3.5	7.7	5.0	0-H	5	1	--	--	1	17	15.8
Roble	5	4.5	6.8	5.7	0-H	5	--	--	--	--	--	--
Yagrumo macho	4	7.3	11.1	9.7	0-H	4	--	--	--	--	--	--

1/ 0 = none; L = light; M = medium; H = heavy.

2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 6.--Condition of round posts treated by hot-and-cold bath using 5% pentachlorophenol dissolved in diesel oil after about 4 1/2 years of service. Cambalache (CA) and Guavate (GU) test plots, Puerto Rico. Treated posts installed in April 1959

Species	Location	Posts in test	Treating time[1]	Retention of preservative			Average side penetration of sapwood radius		Condition of posts, Sept. 1963				Total removed		Average life[2]
				Min.	Max.	Av.			Serviceable	Removed because of					
										Decay	Decay & termites	Termites			
		No.	Hrs.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	Pct.	Yr.
Bambú	CA	20	2-1						19	1	--	--	1	5	--
Cacao motillo	CA	20	4-3	6.9	12.6	9.0	1.27	100	20	--	--	--	--	--	--
Caimitillo	CA	20	4-3	5.7	11.9	8.5	.96	82	20	--	--	--	--	--	--
Camasey blanco	CA	20	3-120	4.0	11.7	7.4	1.01	84	20	--	--	--	--	--	--
" "	GU	18	3-120	3.4	12.1	7.2	1.01	84	18	--	--	--	--	--	--
Cassia de Siam	CA	20	4-3	7.2	12.5	9.1	.53	42	20	--	--	--	--	--	--
Casuarina	CA	19	15-120	6.1	10.6	7.5	1.54	100	19	--	--	--	--	--	--
"	GU	20	15-120	6.3	10.5	7.8	1.54	100	20	--	--	--	--	--	--
Eucalipto (robusta)	CA	19	2-4	6.2	14.6	9.1	.84	100	18	1	--	--	1	5	--
Guaba	CA	20	3-5	6.1	14.3	8.9	.76	64	20	--	--	--	--	--	--
"	GU	20	3-5	6.7	14.0	9.8	.76	64	20	--	--	--	--	--	--
Guamá	CA	20	3-5	4.2	15.0	7.4	1.25	87	20	--	--	--	--	--	--
"	GU	20	3-5	4.5	13.1	8.4	1.25	87	19	1	--	--	1	5	--
Hoja menuda	CA	18	4-120	5.2	9.6	7.4	1.44	100	18	--	--	--	--	--	--
" "	GU	20	4-120	4.0	9.4	6.8	1.44	100	20	--	--	--	--	--	--
Laurel geo	CA	20	15-24	18.9	31.1	25.0	1.60	100	20	--	--	--	--	--	--
" "	GU	20	15-24	12.9	30.0	23.5	1.60	100	20	--	--	--	--	--	--
Mangle blanco	CA	20	5-120	2.9	9.0	5.2	.92	100	20	--	--	--	--	--	--
" "	GU	19	5-120	2.8	12.4	6.3	.92	100	18	1	--	--	1	5	--
Mangle prieto	CA	20	2-10	4.2	6.9	5.2	1.30	100	20	--	--	--	--	--	--
María	CA	20	2-10	14.0	19.1	16.8	1.33	100	20	--	--	--	--	--	--
Moca	CA	20	2-10	3.7	12.7	7.0	1.15	82	20	--	--	--	--	--	--
Péndula	CA	20	2-10	2.1	5.8	3.9	.57	41	20	--	--	--	--	--	--
Pomarrosa	CA	20	5-29	8.5	13.8	10.7	1.37	100	20	--	--	--	--	--	--
"	GU	20	5-29	8.2	13.1	10.4	1.37	100	20	--	--	--	--	--	--
Rabo de ratón	CA	20	4-12	8.5	18.2	12.2	1.25	100	20	--	--	--	--	--	--
" " "	GU	20	4-12	8.5	16.7	12.2	1.25	100	20	--	--	--	--	--	--
Roble	CA	20	15-26	6.4	16.5	11.4	1.31	100	20	--	--	--	--	--	--
"	GU	19	15-26	7.5	13.6	10.5	1.31	100	19	--	--	--	--	--	--
Teca	CA	20	2-120	2.1	7.0	4.1	.64	73	20	--	--	--	--	--	--
Uvilla	CA	19	4-3	2.8	11.8	5.2	1.42	97	19	--	--	--	--	--	--
Yagrumo macho	CA	19	2-4	8.0	15.7	11.4	1.57	100	19	--	--	--	--	--	--

1/ First number, time in hot bath; second number, time in cold bath

2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 7.--Condition of round posts treated by hot-and-cold bath using 50% creosote and 50% diesel oil after about 4 1/2 years in service. Cambalache (CA) and Guavate (GU) test plots, Puerto Rico. Treated posts installed in April 1959

Species	Location	Posts in test	Treating time[1]	Retention of preservative			Average side penetration of sapwood radius		Condition of posts, Sept. 1963				Total removed		Average life[2]
				Min.	Max.	Av.			Serviceable	Removed because of: Decay	Decay & termites	Termites			
		No.	Hrs.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.	In.	Pct.	No.	No.	No.	No.	No.	Pct.	Yr.
Camasey blanco	CA	20	4-120	3.1	10.6	6.6	.81	59	20	--	--	--	--	--	--
" "	GU	20	4-120	3.2	11.4	7.3	.81	59	20	--	--	--	--	--	--
Casuarina	CA	20	15-24	6.8	11.2	9.0	1.52	100	20	--	--	--	--	--	--
"	GU	20	15-24	7.2	10.9	9.0	1.52	100	20	--	--	--	--	--	--
Guaba	CA	20	3-8.5	5.8	14.0	10.1	1.06	74	20	--	--	--	--	--	--
"	GU	19	3-8.5	3.7	12.8	8.5	1.06	74	19	--	--	--	--	--	--
Guamá	CA	19	3-28	2.8	11.5	7.0	1.25	86	19	--	--	--	--	--	--
"	GU	20	3-28	3.7	12.1	7.4	1.25	86	20	--	--	--	--	--	--
Hoja menuda	CA	20	4-120	5.3	8.6	6.6	1.44	98	20	--	--	--	--	--	--
" "	GU	19	4-120	6.3	8.9	7.6	1.44	98	19	--	--	--	--	--	--
Laurel geo	CA	20	3-2	3.2	16.1	9.2	1.01	82	20	--	--	--	--	--	--
" "	GU	20	3-2	2.9	15.8	9.3	1.01	82	20	--	--	--	--	--	--
Mangle blanco	CA	20	15-120	3.1	13.8	5.4	.98	100	20	--	--	--	--	--	--
" "	GU	20	15-120	3.1	9.6	5.4	.98	100	20	--	--	--	--	--	--
Pomarrosa	CA	20	3-20	9.1	15.1	11.8	1.41	100	20	--	--	--	--	--	--
"	GU	19	3-20	9.2	13.3	11.0	1.41	100	19	--	--	--	--	--	--
Rabo de ratón	CA	19	3-2	8.7	15.7	11.7	1.36	100	19	--	--	--	--	--	--
" " "	GU	20	3-2	10.0	16.1	13.1	1.36	100	20	--	--	--	--	--	--
Roble	CA	19	3-4.5	3.9	12.8	7.6	.96	66	19	--	--	--	--	--	--
"	GU	20	3-4.5	3.9	10.5	6.6	.96	66	20	--	--	--	--	--	--

1/ First number, time in hot bath; second number, time in cold bath.
2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is taken.

Table 8.--Condition of round posts treated by hot-and-cold bath using carbolineum. Toro Negro and Cambalache posts in service 13 years; El Verde posts in service 19 years.

Species	Location	Posts in test	Treating time[1]	Retention of preservative			Average side penetration of sapwood radius		Condition of posts, Sept 1963				Total removed		Average life[2]
				Min.	Max.	Av.			Serviceable	Removed because of: Decay	Decay & termites	Termites			
		No.	Hrs.	Lb.per cu.ft	Lb.per cu.ft	Lb.per cu.ft	In.	Pct.	No.	No.	No.	No.	No.	Pct.	Yr.
Casuarina	El Verde	6	5-8/13-18	17	23	20	3/4 - 1	30	5	1	--	--	1	17	26
Caimitillo	Cambalache	2	4-16	5.3	5.5	5.4	Irregular		2	--	--	--	--	--	--
"	Toro Negro	2	4-16	5.5	7.0	6.2	"		2	--	--	--	--	--	--
Eucalipto (patentinervis)	Cambalache	2	4-16	8.0	10.5	9.2	"		2	--	--	--	--	--	--
" "	Toro Negro	2	4-16	5.1	5.4	5.2	"		2	--	--	--	--	--	--
Eucalipto (robusta)	Cambalache	12	4-16	2.6	9.8	6.0	"		12	--	--	--	--	--	--
" "	Toro Negro	12	4-16	4.4	7.8	6.0	"		12	--	--	--	--	--	--

1/ First number, time in hot bath; second number, time in cold bath
2/ Average life values and estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed. Where percentage of posts removed is less than 10 percent, no estimate on average life is given.

Table 9.--Condition of round posts treated by double diffusion after 3 1/2 years in service. Cambalache (CA) and Guavate (GU) test plots, Puerto Rico. Posts installed in March 1960

Species	Location	Treatment	Treating time	Posts in test	Retention			Radial penetration by tank treatment (T-CAC) [1]	Condition of posts, Sept. 1963				Total removed		Average life [2]
					Barrel		Tank average		Serviceable	Removed because of					
					Ground line	Top				Decay	Decay & termites	Termites			
			Days	No.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.		No.	No.	No.	No.	No.	Pct.	Yr.
Achiotillo	CA	T-FC [3]	3+3	20			.41		20	--	--	--	--	--	--
	CA	T-CAC [4]	2+2	19			.80	G	19	--	--	--	--	--	--
	CA	B-CAC [5]	2+2	11	1.06	trace			8	1	1	1	3	27	4.4
	CA	B-FC [6]	3+3	8	.69	.03			5	1	--	2	3	37	4.0
Almácigo	CA	T-FC	3+3	15			.43		8	7	--	--	7	47	3.8
	CA	T-CAC	2+2	20			.89	G	19	1	--	--	1	5	--
	CA	B-CAC	2+2	9	1.50	.03			7	2	--	--	2	22	4.7
	CA	B-FC	3+3	8	.57	.02			--	8	--	--	8	100	1.5
Almendra	CA	T-FC	4+4	20			.50		20	--	--	--	--	--	--
	CA	T-CAC	2+2	19			1.44	G	19	--	--	--	--	--	--
	CA	B-CAC	2+2	4	4.33	.02			3	1	--	--	1	25	4.5
	CA	B-FC	4+4	6	.85	.05			2	3	1	--	4	67	3.3
Bambú (retention based on volume of wall only)	CA	T-FC	3+3	21			.32		4	17	--	--	17	80	2.2
	GU	T-FC	3+3	18			.32		10		--	--	8	44	3.9
	CA	T-CAC	2+2	19			1.17	P	8	1	--	--	11	58	3.6
	GU	T-CAC	2+2	21			1.17	P	15	6	--	--	6	28	4.4
	CA	B-CAC	2+2	10	1.48	.03			1	9	--	--	9	90	2.1
	CA	B-FC	3+3	8	.69	.06			1	5	1	1	7	88	2.0
Cacao motillo	CA	T-FC	2+4	19			.22		19	--	--	--	--	--	--
	CA	T-CAC	2+2	20			.63	F	20	--	--	--	--	--	--
	CA	B-CAC	2+2	10	1.07	.02			10	--	--	--	--	--	--
	CA	B-FC	2+4	10	.72	.01			10	--	--	--	--	--	--
Caimitillo	CA	T-FC	3+3	20			.27		20	--	--	--	--	--	--
	CA	T-CAC	2+2	20			.28	P	20	--	--	--	--	--	--
	CA	B-CAC	2+2	10	1.39	.01			10	--	--	--	--	--	--
	CA	B-FC	3+3	11	.46	.06			10	--	--	1	1	9	--
Camasey blanco	CA	T-FC	3+3	21			.56		19	2	--	--	2	10	5.4
	CA	T-CAC	2+2	18			1.29	C	18	--	--	--	--	--	--
	CA	B-CAC	2+2	9	1.20	.04			9	--	--	--	--	--	--
	CA	B-FC	3+3	10	.60	.03			7	2	1	--	3	30	4.4
Caoba dominicana	CA	T-FC	3+3	19			.32		19	--	--	--	--	--	--
	CA	B-FC	3+3	6	.55	.03			6	--	--	--	--	--	--
Cassia de Siam	CA	T-CAC	2+2	18			.41	G	18	--	--	--	--	--	--
	CA	B-CAC	2+2	12	1.41	.02			12	--	--	--	--	--	--
Casuarina	CA	T-FC	3+3	20			.19		18	1	1	--	2	10	5.4
	GU	T-FC	3+3	20			.19		20	--	--	--	--	--	--
	CA	T-CAC	2+2	19			.60	P	18	1	--	--	1	5	--
	GU	T-CAC	2+2	20			.60	P	18	2	--	--	2	10	5.4
	CA	B-CAC	2+2	10	1.42	.01			9	--	--	1	1	10	5.4
	CA	B-FC	3+3	10	.99	.05			10	--	--	--	--	--	--
Eucalipto (robusta)	CA	T-FC	3+3	17			.60		17	--	--	--	--	--	--
	CA	T-CAC	2+2	22			.81	G	22	--	--	--	--	--	--
	CA	B-CAC	2+2	10	1.18	.06			10	--	--	--	--	--	--
	CA	B-FC	3+3	10	.99	.05			7	1	--	2	3	30	4.4
Guaba	CA	T-FC	3+3	20			.26		20	--	--	--	--	--	--
	CA	T-CAC	2+2	19			.53	G	19	--	--	--	--	--	--
	CA	B-CAC	2+2	10	1.60	.01			10	--	--	--	--	--	--
	CA	B-FC	3+3	9	.52	.04			9	--	--	--	--	--	--
Guamá	CA	T-FC	3+3	18			.16		18	--	--	--	--	--	--
	GU	T-FC	3+3	19			.16		19	--	--	--	--	--	--
	CA	T-CAC	2+2	21			.43	P	21	--	--	--	--	--	--
	GU	T-CAC	2+2	20			.43	P	19	1	--	--	1	5	--
	CA	B-CAC	2+2	10	.90	.06			10	--	--	--	--	--	--
	CA	B-FC	3+3	12	.39	.05			12	--	--	--	--	--	--
Hoja menuda	CA	T-FC	3+3	19			.16		18	--	1	--	1	5	--
	CA	T-CAC	2+2	19			.48	F	19	--	--	--	--	--	--
	CA	B-CAC	2+2	9	1.44	.02			9	--	--	--	--	--	--
	CA	B-FC	3+3	9	.37	.04			6	--	1	2	3	33	4.2

1/ C = complete penetration; G = good penetration; F = fair penetration; P = poor penetration, less than 1/8 inch.
2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed; where percentage of posts removed is less than 10 percent, no estimate on average life is given.
3/ T-FC: Tank treatment - 4 percent NaF and 7 percent $CuSO_4$.
4/ T-CAC: Tank treatment - 10 percent $CuSO_4$ and 6 1/2 percent Na_2CrO_4 + 6 1/2 percent Na_2HAsO_4.
5/ B-CAC: Posts upright in barrels (butt only) - 10 percent $CuSO_4$ and 6 1/2 percent Na_2CrO_4 + 6 1/2 percent Na_2HAsO_4
6/ B-FC: Posts upright in barrels (butt only) - 4 percent NaF and 7 percent $CuSO_4$.

Table 9.--Condition of round posts treated by double diffusion after 3 1/2 years in service. Cambalache (CA) and Guavate (GU) test plots, Puerto Rico. Posts installed in March 1960 (Continued)

Species	Location	Treatment	Treating time	Posts in test	Retention: Barrel: Ground line	Retention: Barrel: Top	Retention: Tank average	Radial penetration by tank treatment (T-CAC) [1/]	Condition of posts, Sept. 1963: Serviceable	Removed because of: Decay	Removed because of: Decay & termites	Removed because of: Termites	Total removed: No.	Total removed: Pct.	Average life [2/]
			Days	No.	Lb.per cu.ft.	Lb.per cu.ft.	Lb.per cu.ft.		No.	No.	No.	No.	No.	Pct.	Yr.
Laurel avispillo	CA	T-FC [3/]	3+3	20			.31		20	--	--	--	--	--	--
	CA	T-CAC [4/]	2+2	20			1.24	F	20	--	--	--	--	--	--
	CA	B-CAC [5/]	2+2	10	1.52	.04			8	1	--	1	2	20	4.7
	CA	B-FC [6/]	3+3	11	.58	.09			9	2	--	--	2	18	4.8
Laurel geo	CA	T-FC	3+3	20			.24		20	--	--	--	--	--	--
	GU	T-FC	3+3	20			.24		19	1	--	--	1	5	--
	CA	T-CAC	2+2	19			.73	C	19	--	--	--	--	--	--
	GU	T-CAC	2+2	19			.73	C	19	--	--	--	--	--	--
	CA	B-CAC	2+2	10	2.02	.07			10	--	--	--	--	--	--
	CA	B-FC	3+3	9	.91	.05			8	1	--	--	1	11	5.3
Mangle blanco	CA	T-FC	3+3	19			.07		19	--	--	--	--	--	--
	GU	T-FC	3+3	20			.07		20	--	--	--	--	--	--
	CA	T-CAC	2+2	19			.62	P	18	--	--	1	1	5	--
	GU	T-CAC	2+2	19			.62	P	19	--	--	--	--	--	--
	CA	B-CAC	2+2	11	.85	.01			6	--	1	4	5	45	3.9
	CA	B-FC	3+3	8	.13	.02			6	1	1	--	2	25	4.5
Mantequero	CA	T-FC	3+3	20			.30		17	3	--	--	3	15	5.0
	CA	T-CAC	2+2	17			.76	P	16	1	--	--	1	6	--
	CA	B-CAC	2+2	10	1.36	.02			10	--	--	--	--	--	--
	CA	B-FC	3+3	10	.56	.03			4	1	1	4	6	60	3.5
María	CA	T-FC	3+3	18			.32		18	--	--	--	--	--	--
	CA	T-CAC	2+2	20			.45	F	20	--	--	--	--	--	--
	CA	B-CAC	2+2	10	.93	.05			10	--	--	--	--	--	--
Pomarrosa	CA	T-FC	3+3	21			.29		20	1	--	--	1	5	--
	CA	T-CAC	2+2	20			.59	F	18	2	--	--	2	20	4.7
	CA	B-CAC	2+2	10	1.79	.02			10	--	--	--	--	--	--
	CA	B-FC	3+3	8	.65	.02			6	2	--	--	2	25	4.5
Rabo de ratón	CA	T-FC	3+3	19			.20		19	--	--	--	--	--	--
	CA	T-CAC	2+2	20			.89	F	20	--	--	--	--	--	--
	CA	B-CAC	2+2	10	1.26	.02			9	1	--	--	1	10	5.4
	CA	B-FC	3+3	10	.55	.04			10	--	--	--	--	--	--
Retama	CA	T-FC	2+4	20			.33		20	--	--	--	--	--	--
	CA	T-CAC	2+2	20			.48	P	20	--	--	--	--	--	--
	CA	B-CAC	2+2	9	.83	.02			9	--	--	--	--	--	--
	CA	B-FC	2+4	9	.86	.10			8	1	--	--	1	11	5.3
Roble	CA	T-FC	3+3	19			.29		19	--	--	--	--	--	--
	GU	T-FC	3+3	20			.29		20	--	--	--	--	--	--
	CA	T-CAC	2+2	20			.53	F	20	--	--	--	--	--	--
	GU	T-CAC	2+2	20			.53	F	20	--	--	--	--	--	--
	CA	B-CAC	2+2	9	2.28	.05			9	--	--	--	--	--	--
	CA	B-FC	3+3	10	.97	.09			10	--	--	--	--	--	--
Teca	CA	T-FC	3+3	18			.58		18	--	--	--	--	--	--
	CA	T-CAC	2+2	20			1.02	G	20	--	--	--	--	--	--
	CA	B-CAC	2+2	11	1.70	.06			11	--	--	--	--	--	--
	CA	B-FC	3+3	10	.77	.03			9	1	--	--	1	10	5.4
Tulipán africano	CA	T-FC	4+4	16			.53		12	4	--	--	4	25	4.5
	CA	T-CAC	2+2	18			1.24	C	18	--	--	--	--	--	--
	CA	B-CAC	2+2	7	1.90	.12			6	1	--	--	1	14	5.1
	CA	B-FC	4+4	6	.83	.05			5	1	--	--	1	17	4.9
Uvilla	CA	T-FC	3+3	20			.43		16	4	--	--	4	20	4.7
	CA	T-CAC	2+2	20			.56	P	19	1	--	--	1	5	--
	CA	B-CAC	2+2	8	.93	.02			8	--	--	--	--	--	--
	CA	B-FC	3+3	9	.58	.03			8	1	--	--	1	11	5.4
Verde seco	CA	T-FC	2+4	19			.45		19	--	--	--	--	--	--
	CA	T-CAC	2+2	20			.61	C	20	--	--	--	--	--	--
	CA	B-CAC	2+2	10	1.30	.02			10	--	--	--	--	--	--
	CA	B-FC	2+4	9	.64	.03			9	--	--	--	--	--	--
Yagrumo hembra	CA	T-FC	3+3	18			.42		16	2	--	-	2	11	5.3
	CA	T-CAC	2+2	20			.87	G	20	--	--	--	--	--	--
	CA	B-CAC	2+2	8	.69	.02			2	6	--	--	6	75	2.2
	CA	B-FC	3+3	6	.79	.03			1	4	--	1	5	83	2.1
Yagrumo macho	CA	T-FC	2+4	16			.47		14	2	--	--	2	12	5.2
	CA	T-CAC	2+2	19			1.10	C	18	1	--	--	1	5	--
	CA	B-CAC	2+2	9	1.41	.03			7	2	--	--	2	22	4.7
	CA	B-FC	2+4	10	.65	.02			2	6	1	1	8	80	2.2
Zarcilla	CA	T-FC	3+3	21			.34		20	1	--	--	1	5	--
	CA	T-CAC	2+2	20			.75	F	20	--	--	--	--	--	--
	CA	B-CAC	2+2	10	1.04	.01			9	--	--	1	1	10	5.4
	CA	B-FC	3+3	10	.53	.08			5	2	--	3	5	50	3.7

1/ C = complete penetration; G = good penetration; F = fair penetration; P = poor penetration, less than 1/8 inch

2/ Average life values are estimates taken from a mortality curve or based on test time when 60 percent of the posts have failed; where percentage of posts removed is less than 10 percent, no estimate on average life is given.

3/ T-FC: Tank treatment - 4 percent NaF and 7 percent $CuSO_4$.

4/ T-CAC: Tank treatment - 10 percent $CuSO_4$ and 6 1/2 percent Na_2CrO_4 + 6 1/2 percent Na_2HAsO_4.

5/ B-CAC: Posts upright in barrels (butt only) - 10 percent $CuSO_4$ and 6 1/2 percent Na_2CrO_4 + 6 1/2 percent Na_2HAsO_4

6/ B-FC: Posts upright in barrels (butt only) - 4 percent NaF and 7 percent $CuSO_4$.

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APPENDIX

List of common and scientific names of species under review in this report

Abeyuelo	Colubrina arborescens (Mill.) Sarg.
Acacia amarilla	Albizzia lebbeck (L.) Benth.
Achiotillo	Alchornea latifolia Sw.
Aguacatillo	Meliosma herbertii Rolfe
Almácigo	Bursera simaruba (L.) Sarg.
Almendra	Terminalia catappa L.
Ausubo	Manilkara bidentata (A.DC.) Chev.
Bambú	Bambusa vulgaris Schrad.
Cacao motillo	Sloanea berteriana Choisy
Caimitillo (mesa)	Micropholis chrysophylloides Pierre
Caimitillo de perro	Chrysophyllum oliviforme L.
Caimitillo verde	Micropholis garcinifolia Pierre
Camasey blanco	Miconia laevigata (L) DC.
Camasey de felpa	Miconia prasina (Sw.) DC.
Camasey jusillo	Calycogonium squamulosum Cogn.
Caoba dominicana	Swietenia mahagoni Jacq.
Caoba hondureña	Swietenia macrophylla King
Capá blanco	Petitia domingensis Jacq.
Caracolillo	Homalium racemosum Jacq.
Cassia de Siam	Cassia siamea Lam.
Casuarina	Casuarina equisetifolia L.
Cieneguillo	Myrcia deflexa (Poir.) DC
Cucubano	Guettarda scabra (L.) Vent.
Espino rubial	Zanthoxylum martinicense (Lam.) DC.
Eucalipto (patentinervis)	Eucalyptus patentinervis R.T. Baker
Eucalipto (robusta)	Eucalyptus robusta J.A. Smith
Granadillo	Buchenavia capitata (Vahl.) Eichl.
Guaba	Inga vera Willd.
Guacimilla	Trema micrantha (L.) Blume
Guamá	Inga laurina (Sw.) Willd.
Guaraguao	Guarea trichilioides L.
Guácima	Guazuma ulmifolia Lam.
Hoja menuda	Myrcia coriacea DC.
Hueso blanco	Linociera domingensis (Lam.) Knobl.
Jagüey	Ficus laevigata Vahl.
Laurel avispillo	Nectandra coriacea (Sw.) Griseb.
Laurel geo	Ocotea leucoxylon (Sw.) Maza
Mangle blanco	Laguncularia racemosa (L.) Gaertn. f.
Mangle colorado	Rhizophora mangle L.
Mangle prieto	Avicennia nitida Jacq.
Mantequero	Rapanea ferruginea (Ruiz & Pav.) Mez
Manzanillo	Sapium laurocerasus Desf.
María	Calophyllum brasiliense Camb.
Maricao	Byrsonima spicata (Cav.) Rich.
Masa	Tetragastris balsamifera (Sw.) Kuntze

Moca	Andira inermis (W. Wright) H.B.K.
Moral	Cordia sulcata DC.
Muñeco	Cordia borinquensis Urban
Negra lora	Matayba domingensis (D.S.) Radlk.
Palo de gallina	Alchorneopsis portoricensis Urban
Palo de matos	Ormosia krugii Urban
Péndula	Citharexylum fruticosum L.
Pomarrosa	Eugenia jambos L.
Rabo de ratón	Casearia arborea (L.C.Rich.) Urban
Retama	Sabinea florida (Vahl.) DC.
Roble	Tabebuia heterophylla (DC.) Brit.
Sabinón	Croton poecilanthus Urban
Tabloncillo	Sideroxylon portoricensis Urban
Tabonuco	Dacryodes excelsa Vahl.
Teca	Tectona grandis L. f.
Tortugo amarillo	Sideroxylon foetidissimum Jacq.
Tulipán africano	Spathodea campanulata Beauv.
Ucar	Bucida buceras L.
Uvilla	Coccoloba diversifolia Jacq.
Verde seco	Tetrazygia elaeagnoides (Sw.) DC.
Yagrumo hembra	Cecropia peltata L.
Yagrumo macho	Didymopanax morototoni (Aubl.) Dec. & Pl.
Zarcilla	Leucaena glauca (L.) Benth.

Chudnoff, M. and Maldonado, E. D.
1964. Preservative treatments and service life of fence posts in Puerto Rico. Inst. Trop. Forestry, U. S. Forest Serv. Res. Paper ITF-1, 31 pp., illus.

Posts treated by four non-pressure techniques using five wood preservation chemicals have been set out at four test locations. About 6000 treated and non-treated control posts representing 68 species are under study. This report describes materials and methods used, chemical retentions and penetrations obtained, and reviews the condition of the posts up through the September 1963 inspection. Some installations date back to 1944, but most of the test posts have been in service for only 3.5 to 4.5 years. Vertical cold-soaking, the hot-and-cold bath technique, and double diffusion salts applied by complete immersion are most effective and should be preferred over conventional cold-soaking or salt combinations applied by end diffusion.

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